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Assessing farmers' perceived constraints to climate adaptation using Garrett ranking and non-parametric analysis

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Abstract

Climate change poses significant challenges to agricultural sustainability, particularly in regions where farming systems are highly climate sensitive. The present study examined the constraints perceived by farmers in adopting climate-resilient agricultural practices and prioritized them across economic, technical, institutional, social-psychological, and resource dimensions. A multistage sampling technique was employed to select 353 farmers from the study area. Data were collected using a structured interview schedule, and constraints were analyzed using Garrett's ranking technique. Further, the Friedman non-parametric test and Kendall's coefficient of concordance were applied to assess statistical differences and agreement in ranking patterns. The results revealed that rising input costs, high investment requirements, and limited access to farm machinery emerged as the most severe constraints. Inadequate training and technical guidance were identified as key technical barriers. Institutional and social-psychological constraints showed comparatively lower prioritization and weak consensus among respondents. The Friedman test indicated statistically significant differences in ranking within economic, technical, and resource categories; however, low Kendall's W values reflected considerable heterogeneity in farmers' perceptions. The findings suggest that financial capacity, infrastructural limitations, and technical support gaps are primary barriers to climate-resilient adoption. Strengthening targeted financial support, improving access to mechanization and irrigation infrastructure, and enhancing farmer centric training programs are critical for accelerating climate adaptation in agriculture. The study contributes empirical evidence for designing context specific strategies to promote resilient farming systems.

Keywords: Climate-resilient agriculture, multistage sampling, Garrett's ranking technique, Friedman test, Kendall's coefficient of concordance

1. Introduction

Climate change is widely recognized as one of the most critical global challenges of the 21st century. Rising greenhouse gas concentrations due to anthropogenic activities have increased global mean surface temperatures by approximately 1.1-1.2 °C above pre-industrial levels, with 2023 recorded as the warmest year on record (Anonymous, 2023; WMO, 2024) ^[2]. This warming has intensified extreme weather events, altered precipitation regimes, and increased the frequency of droughts, floods, and heatwaves. Such climatic disruptions pose severe risks to agriculture, which remains highly sensitive to temperature variability and rainfall instability.

Globally, climate change is already constraining agricultural productivity and threatening food security (Ortiz-Bobea *et al.*, 2021) ^[13]. Developing countries are particularly vulnerable due to their dependence on climate-sensitive sectors and limited adaptive capacity. India, classified as a high-risk country under the INFORM Risk Index (2023) ^[6], faces increasing climate-related disasters, including erratic monsoons, extreme rainfall events, and prolonged heatwaves (Anonymous, 2023a) ^[3]. With nearly half of its

workforce engaged in agriculture and a large proportion of land being rain-fed (World Bank, 2023) ^[19], climatic variability directly affects rural livelihoods and economic stability.

Madhya Pradesh, a major agricultural state in central India, is experiencing rising temperatures and increasing rainfall variability. Projections indicate further warming and heightened drought frequency, which could significantly reduce crop productivity (Mishra *et al.*, 2016) ^[9]. Given the state's reliance on monsoon-dependent agriculture, climate-induced disruptions threaten farmers' livelihood security.

Although climate-resilient agricultural practices have been promoted to enhance adaptation, adoption remains uneven. Farmers face multiple constraints, including financial limitations, inadequate institutional support, limited access to information, technological barriers, and socio-psychological factors influencing risk perception and decision making. Identifying and prioritizing these constraints is essential for designing targeted policy interventions.

Therefore, the present study examines the major constraints perceived by farmers in adopting climate-resilient

agricultural practices in Madhya Pradesh. Using Garrett ranking along with inferential statistical techniques such as the Friedman test and Kendall's coefficient of concordance, the study provides statistically validated prioritization of adaptation barriers, contributing evidence for strengthening climate resilience at the grassroots level.

2. Materials and Methods

2.1 Study Area

The investigation was conducted in the Central Narmada Valley agro climatic zone of Madhya Pradesh, India. The zone was selected purposively due to its agricultural prominence, monsoon-dependent production systems, and increasing exposure to climatic variability such as irregular rainfall, rising temperatures, and extreme weather events. Three districts within this zone, namely Narmadapuram, Narsinghpur, and Harda, were selected to represent varying farming conditions, irrigation systems, and levels of technological adoption.

2.2 Sampling Procedure

A multistage sampling procedure was adopted for selecting the respondents. In the first stage, three districts, namely Narmadapuram, Narsinghpur, and Harda, were purposively selected from the Central Narmada Valley agro-climatic zone of Madhya Pradesh, considering their agricultural importance and vulnerability to climatic variability. In the second stage, two blocks from each selected district were chosen using random sampling. Thereafter, villages were randomly selected from each block to ensure adequate representation of different farming situations within the study area. The sample size was determined scientifically using the finite population correction formula suggested by Singh and Masuku (2014) [7].

$$n = Z^2 * \left(p \frac{1-p}{e^2} \right) / 1 + \left[Z^2 * \frac{p(1-p)}{e^2 N} \right]$$

Where;

n = required sample size

Z = Z-value corresponding to the desired confidence level

p = estimated population proportion

e = margin of error

N = total population size

A confidence level of 95% was considered, with a margin of error of 5%. Since there was no prior estimate of the population proportion, a value of 0.5 was assumed to obtain a sufficiently large and statistically reliable sample. Based on the total number of farming households in the selected villages, the required sample size was calculated to be 353 respondents.

After determining the overall sample size, the respondents were distributed proportionately across the three districts based on the number of farming households in each district. This ensured that districts with larger farming populations contributed proportionately more respondents to the study. Within each selected village, individual farmers were then chosen through simple random sampling from the prepared list of agricultural households.

$$ni = \frac{Ni}{N} \times 353$$

Where,

Ni = respondents to be selected from village i

Ni = total farmers (population) in village i

N = total farmers across all selected villages

Total sample size = 353

2.3 Data Collection

Primary data were collected during the agricultural year 2024-25 using a structured and pre-tested interview schedule. The schedule was developed based on literature review, expert consultation, and field interactions. Informal discussions were conducted with farmers to understand the practical difficulties they faced in adopting climate-resilient agricultural practices. Data were collected through personal interviews to ensure completeness and reliability.

2.4 Identification and categorization of constraints

Based on insights obtained from literature and field discussions, a list of constraints was compiled and classified into major categories such as economic, technical, institutional, social and psychological, and resource and infrastructure constraints. These constraint statements were included in the interview schedule. Respondents were asked to rank the listed constraints according to the severity they experienced, assigning higher ranks to more serious constraints. The ranking data were analysed using Garrett's Ranking Technique to determine the relative importance of each constraint.

2.5 Garrett's Ranking Technique

To determine the relative importance of the constraints, Henry Garrett's Ranking Technique was applied. The ranks assigned by each respondent were first converted into percent positions using the following formula:

$$\text{Percent Position} = \frac{100(R_{ij} - 0.5)}{N_j}$$

Where,

R_{ij} denotes the rank given to the i th constraint by the j th respondent,

N_j represents the total number of constraints ranked by that respondent.

The calculated percent positions were then transformed into Garrett scores with the help of the conversion table developed by Garrett and Woodworth (1969) [5]. For each constraint, the individual scores were summed and divided by the total number of respondents to obtain the mean Garrett score.

2.6 Statistical Analysis

To statistically examine differences among the ranked constraints, the Friedman non-parametric test was applied. This test assessed whether the observed differences in rankings were statistically significant.

$$\chi^2 = \frac{12}{nk(k+1)} \sum R_j^2 - 3n(k+1)$$

Where,

R_j = Sum of ranks for each statement

n = Total number of respondents

k = Number of constraints in that category

Further, Kendall's coefficient of concordance (W) was computed to measure the degree of agreement among respondents regarding the ranking of constraints.

$$W = \frac{\chi^2}{n(k-1)}$$

The value of W ranges between 0 and 1, with higher values indicating stronger consensus among respondents.

3. Results and Discussion

The findings of the study are presented in this section to examine the nature and relative severity of constraints perceived by farmers in adopting climate resilient

agricultural practices. Category wise prioritization was carried out using Garrett's ranking technique to determine the relative importance of constraints. Subsequently, inferential analysis was performed to assess whether statistically significant differences existed in the ranking patterns within each category.

3.1 Economic Constraints in the Adoption of Climate-Resilient Practices

As presented in Table 1, rising prices of seeds, fertilizers, and pesticides (Mean Score = 59.16) emerged as the most severe economic constraint (Rank I). The high cost involved in adopting climate-resilient practices (57.57) was ranked second, followed closely by limited farm income (56.97). Limited access to credit facilities (53.35) occupied the fourth position, whereas delayed or insufficient crop insurance compensation (50.94) was perceived as relatively less severe.

Table 1: Economic Constraints and Their Relative Importance

Sr. No.	Economic Constraints	Mean Garrett Score	Rank
1.	The cost involved in adopting climate-resilient farming practices is too high.	57.57	II
2.	Rising prices of seeds, fertilizers, and pesticides make it difficult to try new practices.	59.16	I
3.	Limited farm income restricts ability to invest in climate-resilient technologies.	56.97	III
4.	Compensation received through crop insurance is often delayed or insufficient.	50.94	V
5.	Credit facilities are not easily available for adopting new technologies.	53.35	IV

The findings indicate that escalating input costs and limited financial capacity constitute the primary economic impediments to climate resilient adoption. Cost intensive adaptation measures appear to be beyond the immediate affordability threshold of many farmers, thereby constraining investment decisions.

3.2 Technical Constraints in the Adoption of Climate-Resilient Practices

As shown in Table 2, limited training opportunities and

technical guidance related to climate change adaptation (Mean Score = 59.24) was ranked as the most critical technical constraint. Lack of adequate knowledge about climate resilient practices (57.32) followed as the second most severe barrier. Limited availability of suitable technologies at the local level (53.90) ranked third, while difficulty in interpreting weather forecasts and advisories (49.53) was perceived as comparatively less severe.

Table 2: Technical Constraints and Their Relative Importance

Sr. No.	Technical Constraints	Mean Garrett Score	Rank
1.	Lack of adequate knowledge about climate-resilient agricultural practices.	57.32	II
2.	Training opportunities and technical guidance related to climate change adaptation are limited in the area.	59.24	I
3.	Suitable climate-resilient technologies are not easily available at the local level.	53.90	III
4.	Weather forecasts and advisories are difficult to understand and use.	49.53	IV

These results suggest that inadequate institutional capacity for knowledge dissemination and technical support significantly restricts adaptive transitions. Farmers' adoption decisions are strongly influenced by the availability of structured training and locally accessible technologies.

3.3 Institutional Constraints in the Adoption of Climate-Resilient Practices

The ranking results in Table 3 indicate that unreliable

weather forecasts for farm planning (Mean Score = 56.21) was perceived as the most severe institutional constraint. Complicated procedures for availing benefits under climate related schemes (55.43) ranked second, followed by limited accessibility of extension services (55.08). Delayed scheme implementation and inadequate information dissemination were ranked moderately, while limited interaction with agricultural officers (53.71) was perceived as the least severe institutional constraint.

Table 3: Institutional Constraints and Their Relative Importance

Sr. No.	Institutional Constraints	Mean Garrett Score	Rank
1.	Extension services related to climate change are not easily accessible.	55.08	III
2.	Interaction with agricultural officers or extension workers is very limited.	53.71	VI
3.	Government schemes related to climate resilience are not implemented on time.	54.73	V
4.	The procedures to avail benefits under climate-related schemes are complicated.	55.43	II
5.	Information about climate-resilient programs does not reach farmers properly.	54.84	IV
6.	Weather forecasts are not reliable for planning farm operations.	56.21	I

These findings highlight systemic inefficiencies in service delivery mechanisms and procedural complexities that hinder effective climate adaptation. Institutional reliability and transparency appear central to strengthening adaptive capacity at the farm level.

3.4 Social & Psychological Constraints in the Adoption of Climate-Resilient Practices

As indicated in Table 4, fear of social criticism in the event of failure (Mean Score = 51.42) emerged as the most severe social and psychological constraint. Fear of crop failure (50.21) ranked second, while generational gaps affecting adoption decisions (48.37) was perceived as the least severe constraint within this category.

Table 4: Social & Psychological Constraints and Their Relative Importance

Sr. No.	Social & Psychological Constraints	Mean Garrett Score	Rank
1.	Farmers hesitate to adopt new practices due to fear of crop failure.	50.21	II
2.	Fear of social criticism if new practices fail.	51.42	I
3.	Generational gap between older and younger farmers affecting adoption decisions.	48.37	III

The results demonstrate that social risk perception and reputational concerns influence adoption behaviour. Although these constraints recorded relatively lower mean scores compared to economic and technical barriers, psychological hesitation remains a non-negligible factor in adaptation decisions.

3.5 Resource & Infrastructure Constraints in the Adoption of Climate-Resilient Practices

As presented in Table 5, lack of access to appropriate farm machinery (Mean Score = 59.10) was identified as the most severe resource related constraint. Poor storage and market facilities (58.24) ranked second, followed by limited irrigation availability (57.59). Labour shortages (52.82) and small landholding size (50.25) were perceived as relatively less severe.

Table 5: Resource & Infrastructure Constraints and Their Relative Importance

Sr. No.	Resource & Infrastructure Constraints	Mean Garrett Score	Rank
1.	Limited availability of irrigation facilities restricts adoption of climate-resilient practices.	57.59	III
2.	Farm machinery required for improved practices is not easily accessible.	59.10	I
3.	Poor storage and market facilities reduce motivation to adopt new farming practices.	58.24	II
4.	Small landholding size limits experimentation with climate-resilient methods.	50.25	V
5.	Labour availability is a major problem during critical farm operations.	52.82	IV

These findings underscore the structural limitations in physical infrastructure and mechanization that impede the

adoption of improved practices. Inadequate resource support reduces farmers' capacity to experiment with climate resilient methods.

Across categories, economic and resource related constraints recorded comparatively higher mean scores than social and institutional dimensions, indicating that material and cost related barriers dominate adaptation challenges. The relative prioritization suggests that financial and infrastructural limitations outweigh behavioural or purely institutional factors in shaping farmers' adaptive decisions.

3.6 Category-wise Inferential Analysis: Friedman Test and Kendall's W

The results of the Friedman test (Table 6) indicate statistically significant differences in the ranking of constraints within the economic ($\chi^2 = 40.69$, $p < 0.001$), technical ($\chi^2 = 51.89$, $p < 0.001$), and resource & infrastructure ($\chi^2 = 49.11$, $p < 0.001$) categories. This confirms that respondents meaningfully differentiated between the relative severities of constraints within these domains.

Table 6: Friedman Test and Kendall's Coefficient of Concordance for Category-wise Ranking of Perceived Constraints

Category	χ^2	df	Significance	Kendall's W
Economic constraints	40.69	4	$p < 0.001$	0.029
Technical constraints	51.89	3	$p < 0.001$	0.049
Institutional constraints	0.23	5	NS	0.0001
Social & psychological constraints	4.55	2	NS	0.006
Resource & infrastructure constraints	49.11	4	$p < 0.001$	0.035

However, Kendall's coefficient of concordance (W) values for these categories were low (ranging from 0.029 to 0.049), indicating weak agreement among respondents. While differences in rankings are statistically significant, the low W values suggest variability in individual perceptions regarding the intensity of constraints.

In contrast, institutional ($\chi^2 = 0.23$, $p > 0.05$) and social & psychological constraints ($\chi^2 = 4.55$, $p > 0.05$) did not exhibit statistically significant differences in ranking. The extremely low Kendall's W values (0.0001 and 0.006, respectively) further indicate negligible consensus among respondents in these categories.

Overall, while certain categories demonstrate statistically significant variation in perceived severity, the weak levels of concordance across all categories reflect diverse experiential realities and contextual variability influencing farmers' adaptation challenges.

4. Conclusion

The study examined the constraints perceived by farmers in adopting climate-resilient agricultural practices and prioritized them across five major dimensions. The findings indicate that economic and resource-related barriers, particularly rising input costs, high initial investment requirements, and limited access to farm machinery, emerged as the most severe impediments to adaptation. Technical limitations, especially inadequate training and limited technical guidance, also significantly constrained adaptive transitions.

Institutional, social and psychological constraints, although present, exhibited relatively lower prioritization and weak consensus among respondents. Inferential analysis revealed statistically significant differences in ranking patterns within economic, technical, and resource-related categories; however, the low levels of concordance suggest substantial heterogeneity in farmers' perceptions. This indicates that adaptation challenges are shaped by diverse socio-economic and contextual realities rather than uniform structural barriers.

Overall, the findings underscore that climate resilient adoption is primarily constrained by financial capacity, infrastructural limitations, and technical support gaps. Strengthening targeted financial assistance, improving access to mechanization and irrigation infrastructure, and enhancing farmer-oriented training and extension services may substantially enhance adaptive capacity at the farm level. Addressing these constraints through integrated and context-specific interventions is essential for promoting sustainable and resilient agricultural systems.

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